PATENT SPECIFICATION

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(54) IMPROVEMENTS IN OR RELATING TO WIDE-ANGLE LENS

(71) We, S.A. TUBIX, a French Body Corporate, of 24—26, Rue Martin Bernard, 75013, Paris, France,

do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

Many types of objectives have been designed and produced in order to obtain a good definition of an image over a wide field. These objectives have one thing in common, viz. the diaphragm which divides the objective into two unequal parts: a group of frontal lens elements situated on the object side of the diaphragm, and a group of rear lens elements placed on the image side of the diaphragm. The difficulty encountered in correcting the aberrations produced by a wide angular field have always led to the use of numerous lenses, and in particular the group of frontal lens elements (with the first negative lens element in the form of a semi-sphere) has increased in importance in order to obtain a field approximately to 180°.

The present invention provides a wide angled objective lens system having a wide aperture, said system comprising a diaphragm and a lens system comprising at least four lens elements all disposed upon the image side of said diaphragm and said lens elements increasing in diameter with increasing distance from said diaphragm and being disposed along a common optical axis, the angular field of said lens system being at least 80° and the relative aperture being at least f/3.5.

According to this invention the diaphragm of the objective is disposed nearest to the object and all the lens elements are further from the object than the diaphragm and on the same side thereof and disposed along a common optical axis, the angle of the field is at least 80° and the aperture is at least f/3.5. It is preferred that the angle of the field be greater than 120° and correspondingly that the aperture is greater than f/2.5. This should be compared with a conventional objective which has an aperture of about f/11, or exceptionally an aperture of f/4.5.

As an example of the results that may be achieved in accordance with the present invention using a diaphragm having a diameter of 6 mm and a focal length of 15 mm (aperture: f/2.5) it is possible to secure a degree of separation of 75 lines to the millimetre over ⅔ of an angular field of 130°.

Lenses made of certain plastics materials may readily be produced having predetermined curvatures and they may have complex non-spherical shapes for use in correcting the aberrations of a lens system. It is however not possible to obtain a constant refractive power as a function of temperature. In order to avoid the difficulties arising from this drawback of plastics material lenses the present invention contemplates the use of a plastics material lens doublet having substantially zero refractive power. As a consequence the axial power and the chromaticism is not substantially changed. This enables the curvatures of the lenses constituting a plastics material doublet to be so chosen as to bring about a correction of both the axial and the extra-axial aberrations of the other lens elements. In such a construction it is preferred that both facing surfaces of such a doublet be either concave or convex.

The invention will now be described with reference to the accompanying drawings in which:

Figure 1 illustrates one embodiment of a lens system in accordance with the invention,

Figure 2 illustrates a second embodiment of a lens system in accordance with the invention, and

Figure 3 illustrates a third embodiment of a lens system in accordance with the invention, which system includes non-spherical lens elements.

In Figure 1, O represents the centre of a diaphragm D and OZ represents the longitudinal axis of the diaphragm. The lens system

is mounted within a trapezoidal envelope and consists of a series of lens elements of successively increasing diameter. The angle of the field 2α is greater than 120°. The plans of the focus F of the system is located slightly to the rear of the lens system. The lens elements A and B represent the glass lens elements of the system and between these are located the lens elements made of a transparent plastics material which constitute the optical lens group C, with the respective lens elements designated L_1 and L_2 which overall have a substantially zero refractive power and which have their convex surfaces facing towards each other.

Figure 2 represents an essentially similar arrangement to that shown in Figure 1 save only that the relative positions of the plastics material lens elements are interchanged with the result that the concave surfaces of these lenses face each other.

In the arrangement shown in Figure 3 a lens multiplet generally designated A is located behind the diaphragm D. This multiplet consists of a first concavo-convex lens element L_3 of glass behind which is located a cemented doublet consisting of a plano-concave lens element L_4 and a plano-convex lens element L_5. This cemented doublet is followed by a plano-convex lens element L_6 which has a non-spherical convex surface and has its plane surface facing towards the diaphragm. The non-spherical convex surface is parabolic. A lens element L_6 is followed by a second lens multiplet generally designated B which, as shown, is a cemented doublet consisting of lens elements L_7 and L_8. The lens element L_7 is a double convex lens element whilst lens element L_8 is a double concave element.

In the following table there are set out the refractive indices, the radii of curvature, the thicknesses of the lens elements, the distances separating successive lens elements and the diameters of the respective lens elements used in an arrangement pursuant to Figure 3. All measurements are in mm.

The lens system has a focal length of 8 mm, an aperture of f/2, a field of 120°, a draw length T of between 3.7 and 11 mm depending upon the adjustment of the image plane. The plane of the diaphragm D is 2 mm ahead of the apex of the lens element L_3.

TABLE

	Indices Refraction	Radii of Curvature R_1	R_2	Thickness	Distance between successive lens elements	Diameter
L_3	1.73	−4.1	−4.82	1.0	0.2 (L_3 L_4)	4.0
L_4	1.73	−15.38	∞	1.0	0.0 (L_4 L_5)	6.0
L_5	1.62	∞	−8.71	4.2	0.2 (L_5 L_6)	6.0
L_6	1.49	∞	−12.88	2.2	2.2 (L_6 L_7)	7.5
L_7	1.62	+15.3	−10.25	6.0	0.0 (L_7 L_8)	9.0
L_8	1.73	−10.25	+11.02	1.5	—	9.0

The lens system of the present invention is especially useful in connection with photographic objectives and observation lens systems in which the wide-angled image obtainable with the lens system is passed to a field lens system and to a conventional ocular system. Since the lens system disclosed comprises a diaphragm located in the plane of the entry pupil of the lens system it is suitable for use as the objective component of a panoramic observation glass which is intended for viewing the image transmitted through a small aperture.

WHAT WE CLAIM IS:—

1. A wide angle objective lens system having a wide aperture, said system comprising a diaphragm and a lens system comprising at least four lens elements all disposed upon the image side of said diaphragm and said lens elements increasing in diameter with increasing distance from said diaphragm and being disposed along a common optical axis, the angular field of said lens system being at least 80° and the relative aperture being at least f/3.5.

2. An objective lens system as claimed in

claim 1 in which the outermost lens elements of said optical system are formed from optical glass and a pair of intervening lens elements are formed from transparent plastics material.

3. An objective lens system as claimed in either of the preceding claims in which a pair of intervening lens elements are of transparent plastics material and together form a doublet having substantially zero refractive power the curvatures of said lens elements being so chosen and the lenses so disposed as to effect a correction of both the axial and the extra-axial aberrations of the other lens elements constituting said lens system.

4. An objective lens system according to any of the preceding claims in which the angular field of said lens system is at least 120° and the relative aperture is greater than f/2.5.

5. An objective lens system according to either of claims 2 or 3 in which said pair of intervening lens elements are both concave-convex lenses, both facing surfaces of said elements being either concave or convex.

6. An objective lens system according to any of the preceding claims in which the lens element most distant from said diaphragm is a double convex lens element.

7. An objective lens system according to any of claims 1—4 in which the lens element most distant from said diaphragm is an element of a lens multiplet, said multiplet comprising a double convex lens element and a double concave lens element.

8. A wide angled objective lens system substantially as hereinbefore described with reference to Figure 1, Figure 2 or Figure 3 of the accompanying drawings.

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FIG. 1

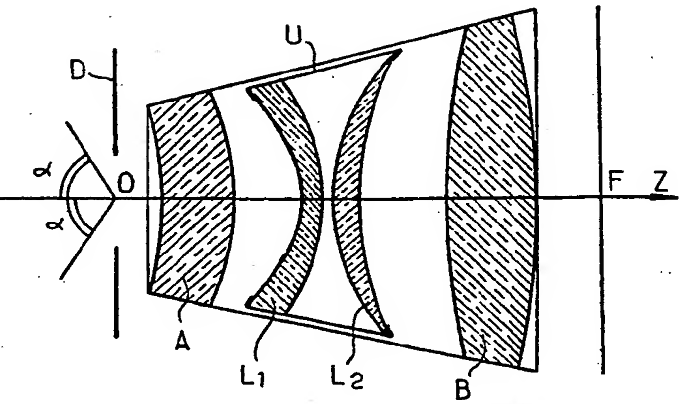

FIG. 2

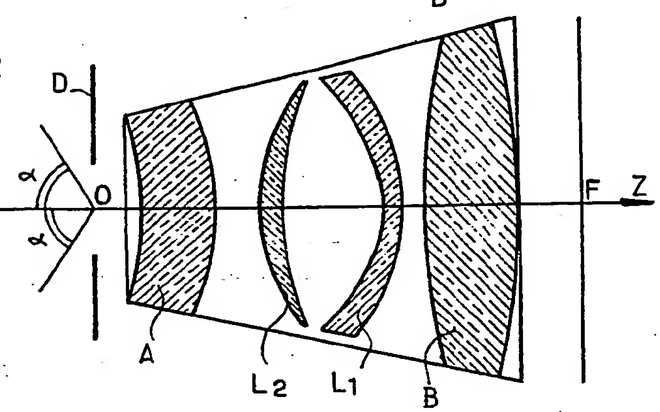

FIG. 3